# Identification of optimal ablation wavelength and pulse-durations for improved in-situ dating

Completed Technology Project (2017 - 2020)

## Project Introduction

Science goals Under PIDDP, NSF, and internal funding, we have developed an instrument called CODEX (the Chemistry, Organics and Dating EXperiment) to search for evidence of past life on Mars, reveal the history of habitability, and ascertain how the local geology evolved; these are also key scientific goals for the Moon, other planets, and asteroids. CODEX is uniquely able to analyze the microscopic chemical and organic makeup of a sample in spatial context, while simultaneously determining its age. The instrument uses nanosecond laser pulses to ablate ions and neutrals, which can be measured directly or via secondary ionization. Recently, experiments using ultrashort pulse laser ablation have demonstrated significant improvement in measurement precision and accuracy, and new technological developments have resulted in significant reductions in the required size, power, and mass of lasers capable of producing these ultrashort pulses. These improvements primarily have been demonstrated with laser ablation mass spectrometry (LAMS), and in laser desorption inductively coupled plasma mass spectrometry, techniques that rely on the production of ions and micro-particulates. Because CODEX uses LARIMS, which measures neutrals, we suspect that using ultrashort pulse ablation would improve the precision and accuracy of our measurements. However, little is yet known about the production of neutrals using ultrashort pulses; some work suggests that fractionation of neutrals is reduced as well. Thus, in this proposal we will test and assess whether ultrashort pulses can improve LARIMS dating as well. Methodology In this proposal we will rent and compare several femto- and pico- second lasers for ion and neutral production in our prototype instrument, and identify the optimal parameters for improving the accuracy of chemical, organic, and radiometric measurements. We will explore a parameter space including wavelength, pulse-length, peak power, the effect of multiple shots, fluence, sample/standard composition, production of long-live excitation states, and the impact of plasma generation. The laser systems under consideration will include small systems consistent with the possibility of future development for spaceflight. The resulting chemistry, organics, and dating measurements are particularly applicable for missions to Mars, the Moon, and possibly Vesta. Relevance Our measurements are relevant to multiple NASA goals for Mars and the Moon, such as: A) For Mars, the NRC Decadal Survey (DS) specifically supports: "long-term development of instruments ... focusing on the most important future in situ measurements... [including] ... in situ geochronology experiments" [National Research Council, 2012]; B) MEPAG Goals III.A.3-10, but especially 3, specifically call for "Constrain[ing] the absolute ages of major Martian crustal geologic processes... and the cratering rate. ... This investigation could be approached with both in situ and returned sample analysis..."; C) For the Moon, the NRC DS has a primary goal of: "Determin[ing] the chronology of basin-forming impacts and constrain[ing] the period of late heavy bombardment in the inner solar system, and thus address[ing] fundamental questions of inner solar system impact processes and chronology" [National Research Council, 2012].


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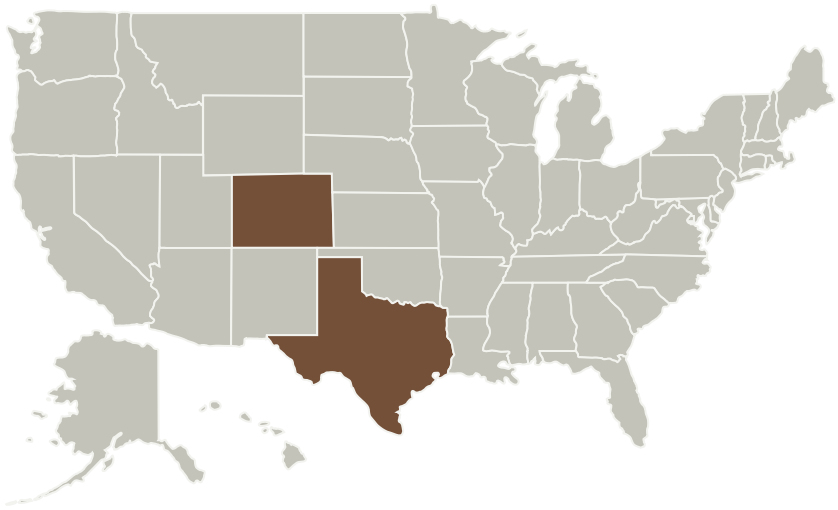
## Anticipated Benefits

The science of femto-second laser pulses stands to greatly improve laser ablation related measurements, and in particular may greatly improve the accuracy and precision of in-situ dating, a critical measurement for future missions.

## Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| Southwest Research Institute - San Antonio(SWRI) | Lead Organization | Academia | San Antonio, Texas |

| Primary U.S. Work Locations | |
|---|---|
| Colorado | Texas |

## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Lead Organization:**

Southwest Research Institute - San Antonio (SWRI)

**Responsible Program:**

Planetary Instrument Concepts for the Advancement of Solar System Observations

## Project Management

**Program Director:**

Carolyn R Mercer

**Program Manager:**

Haris Riris

**Principal Investigator:**

Fletcher S Anderson

**Co-Investigators:**

Ronald B Kalmbach
Alexandria Anderson
Sterling Backus
Tom J Whitaker

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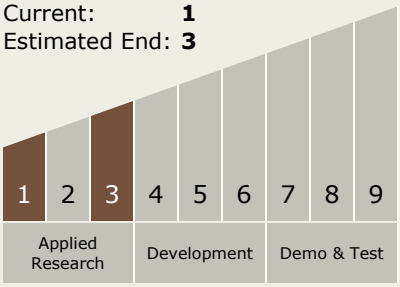
## Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **3**




## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.5 Lasers

## Target Destination

Others Inside the Solar System